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THE VEGETABLE WEEVIL

By M. M. High,[1] *formerly associate entomologist, Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine* [2]

CONTENTS

INTRODUCTION

The vegetable weevil (*Listroderes obliquus* Klug), one of the numerous species of insect pests accidentally introduced from abroad, has become increasingly important to the vegetable-growing industry in the Southern States and in California. For several years after its discovery in the United States this insect confined its depredations principally to such vegetables as turnip, carrot, tomato, potato, and cabbage grown within a comparatively limited section adjacent to the Gulf of Mexico. During the last few years, however, it has become an important pest of practically all the principal vegetable crops and certain of the flower crops in a larger area covering nine Southern States, as well as in California. In addition to the cultivated hosts, the vegetable weevil has been found feeding on many weeds commonly associated with vegetable and flower growing, thus complicating control measures.

Whether the insect eventually will become a destructive pest of other important economic crops and whether it will extend its range greatly beyond the present known limits are matters of conjecture, but

[1] Resigned July 31, 1936.

[2] The following men, serving under temporary seasonal appointments, assisted in the investigations reported herein: O. T. Deen and G. L. Phillips conducted some of the life-history studies and assisted in scouting and in the control work; E. K. Bynum made some of the food-plant and scouting observations; J. L. Tate, T. P. Dawkins, and E. H. Frederic contributed to the records on distribution, food plants, and control. C. F. W. Muesebeck, Adam G. Böving, and L. L. Buchanan, of the Division of Insect Identification, made valuable suggestions with regard to nomenclature, distribution, and morphology. Thanks are due D. J. Caffrey for assembling and preparing the data in this paper for publication.

investigations thus far have shown it to be essentially polyphagous in its host-plant reactions, with a facile ability to become adapted to new conditions of environment.

The purpose of the investigations reported in this circular was to determine the more important habits of the vegetable weevil and to develop cultural and insecticidal means of control. They were carried on in southern Mississippi, principally at Gulfport and Biloxi, during the period 1924–36.

DISTRIBUTION IN THE UNITED STATES

At the end of December 1935 a total of 206 counties in the Southern States (fig. 1) and 19 counties in California (fig. 2) were known to be

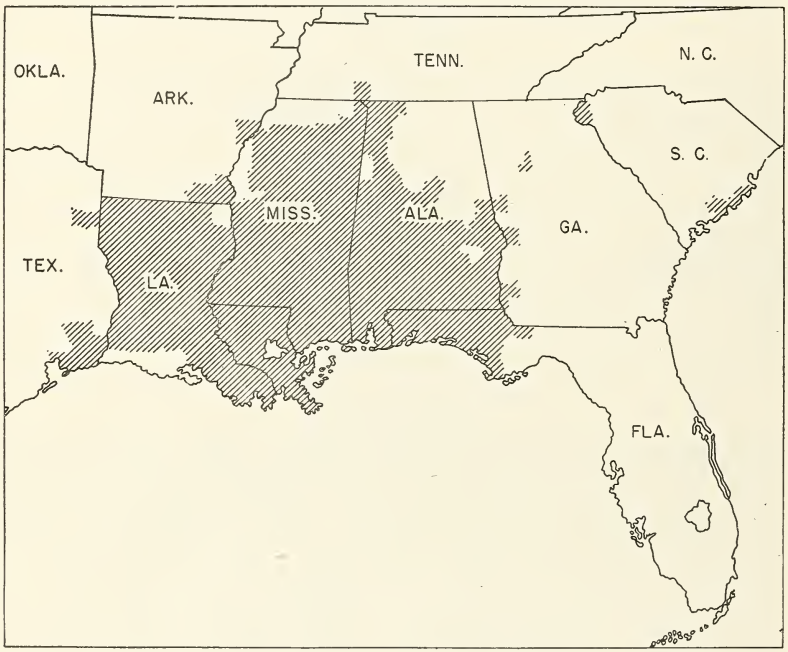

FIGURE 1.—Distribution of the vegetable weevil in the Southern States at the end of 1935. Infested areas indicated by shading.

infested by the weevil. The distribution by counties and States is as follows:

Alabama: Autauga, Baldwin, Barbour, Bibb, Butler, Chambers, Chilton, Choctaw, Clarke, Coffee, Colbert, Conecuh, Covington, Crenshaw, Dale, Dallas, Elmore, Escambia, Fayette, Franklin, Geneva, Greene, Hale, Henry, Houston, Lauderdale, Lee, Lowndes, Macon, Marengo, Marion, Mobile, Monroe, Montgomery, Perry, Pickens, Pike, Russell, Shelby, Sumter, Tuscaloosa, Washington, and Wilcox.

Arkansas: Ashley, Bradley, Chicot, Hot Spring, and Phillips.

California: Alameda, Contra Costa, Humboldt, Los Angeles, Marin, Monterey, Napa, Orange, Riverside, Sacramento, San Bernardino, San Francisco, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Stanislaus, and Yolo.

Florida: Bay, Calhoun, Escambia, Gadsden, Gulf, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, and Washington.

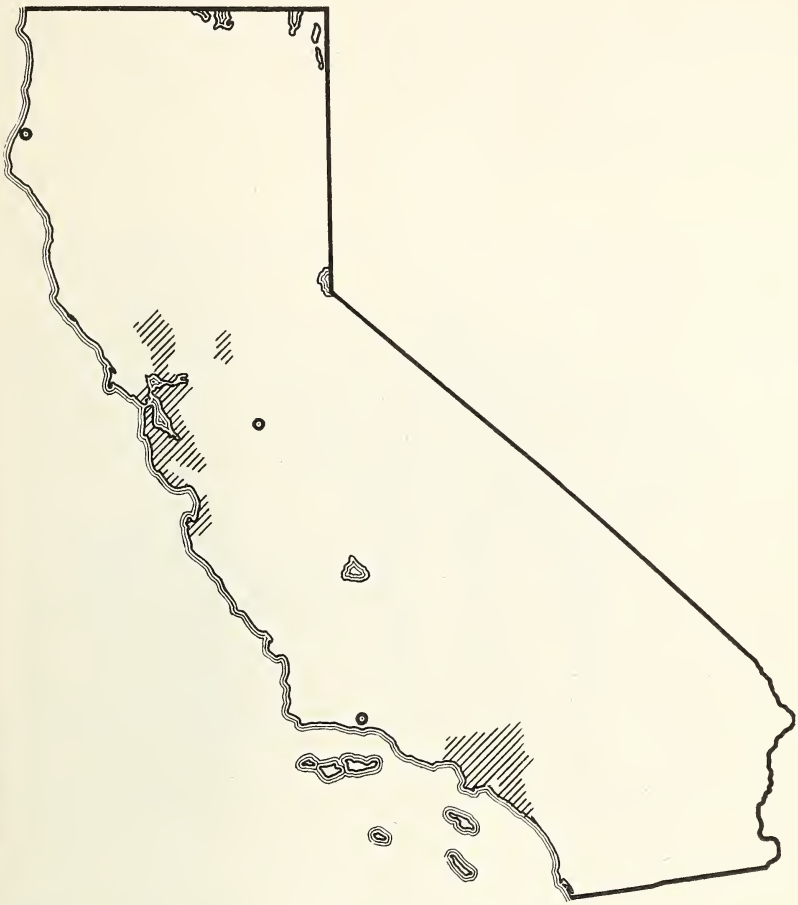

FIGURE 2.—Distribution of the vegetable weevil in California at the end of 1935. Infested territories indicated by shading, isolated infestations by dots.

Georgia: Early, Fulton, Lamar, Muscogee, Spalding, Tift, and Troup.

Louisiana: Acadia, Allen, Ascension, Assumption, Avoyelles, Beauregard, Bienville, Bossier, Caddo, Calcasieu, Caldwell, Catahoula, Claiborne, Concordia, De Soto, East Baton Rouge, East Feliciana, Evangeline, Franklin, Grant, Iberia, Iberville, Jackson, Jefferson, Jefferson Davis, Lafayette, La Fourche, La Salle, Lincoln, Livingston, Madison, Morehouse, Natchitoches, Ouachita, Plaquemines, Pointe Coupee, Rapides, Red River, Richland, Sabine, Saint Bernard, Saint Charles, Saint Helena, Saint James, Saint John the Baptist, Saint Landry, Saint

Martin, Saint Mary, Saint Tammany, Tangipahoa, Tensas, Terrebonne, Union, Vernon, Washington, Webster, West Baton Rouge, West Feliciana, and Winn.

Mississippi: Adams, Amite, Attala, Calhoun, Carroll, Chickasaw, Choctaw, Claiborne, Clarke, Clay, Coahoma, Copiah, Covington, Forrest, Franklin, George, Greene, Grenada, Hancock, Harrison, Hinds, Holmes, Humphreys, Issaquena, Itawamba, Jackson, Jasper, Jefferson, Jefferson Davis, Jones, Kemper, Lafayette, Lamar, Lauderdale, Lawrence, Leake, Lee, Leflore, Lincoln, Lowndes, Madison, Marion, Monroe, Montgomery, Neshoba, Newton, Noxubee, Oktibbeha, Panola, Pearl River, Perry, Pike, Pontotoc, Prentiss, Quitman, Rankin, Scott, Sharkey, Simpson, Smith, Stone, Sunflower, Tallahatchie, Tishomingo, Union, Walthall, Warren, Wayne, Webster, Wilkinson, Winston, Yalobusha, and Yazoo.

South Carolina: Charleston and Oconee.

Tennessee: Hardin.

Texas: Chambers, Hardin, Harrison, Jefferson, and Orange.

HISTORY

The vegetable weevil, which was first described by Klug (*11, p. 6*)[2] in 1829 from specimens collected in southern Brazil, is believed to be indigenous to South America.

In 1908 this weevil was discovered in southern Australia near Melbourne by French (*6, 7*), who reported it as very destructive to tomato, cabbage, and other vegetables. The insect was also mentioned as a pest in Australia by Lea (*12*) in 1909. In 1911 French (*8, pp. 41–43*) further reported it as a depredator of vegetables and the buds of plum and other fruit trees in Australia. Froggatt (*9*) in 1915 stated that the weevil had a wide range over the eastern and southern coasts of Australia, and that in New South Wales it had been observed damaging tomatoes and the young buds and shoots of fruit trees and vines. In 1924 and 1925 McCarthy (*16, 17*) stated that the vegetable weevil had extended its range in Australia as far north as Byron Bay in the North Coast district of New South Wales. He discussed the food plants, nature of injury, general habits, and control methods, under Australian conditions, and described the stages of the insect.

The presence of the vegetable weevil was recorded in 1924 in South Africa (*18*), where it was said to be causing damage to turnips. The vegetable weevil was first reported in the United States in Stone County, Miss., in 1922 by Harned (*10*). In 1923 Bynum (*3, 4*) reported on the distribution of the insect as known at that time and discussed its habits, as well as the results of preliminary attempts to effect its control. Chittenden (*5*) discussed the discovery of the vegetable weevil in this country and its distribution in 1923, and included its description, origin, and world distribution, habits in Australia and Mississippi, and possible methods of insecticidal control.

Within a short time after its original discovery in Stone County, Miss., the presence of the pest was detected in the adjacent counties of Harrison, Hancock, Jackson, and Pearl River, all of which were within a short distance of Gulfport Harbor. Later reports of the occurrence of the weevil in widely separated sections of the Gulf region have indicated the possibility that the insect gained entrance into this country in material from South America through the ports of Gulfport, Miss., New Orleans, La., and Mobile, Ala. From these focal points the insect may have spread throughout the territory in the Southern States shown in figure 1.

[2] Italic numbers in parentheses refer to Literature Cited, p. 25.

According to Lewis (*13*), the vegetable weevil was first found in California in February 1926 near San Jose in Santa Clara County.[3] It is probable that the insect was present in California prior to 1926, since it was subsequently learned that E. C. Van Dyke had specimens that had been collected in October 1925. In 1927 and again in 1928 Lewis (*13*, *14*) published accounts of the vegetable weevil in California, which included life history, habits, injury, and methods of control under California conditions. Lovell (*15*) in 1932 reported further upon the habits and injury by the pest in California and, in addition to the control measures discussed by Lewis, gave an account of the results obtained in experiments to determine the efficiency of field sanitation, soil fumigation, and light traps in combating the pest.

FIGURE 3.—Carrots injured by larvae of the vegetable weevil. On the left are shown stunted roots and tops caused by injury to the buds and leaves. On the right are uninjured carrot plants taken from the same row.

TECHNICAL AND COMMON NAMES

Although the insect, now known commonly in this country as the vegetable weevil, has been referred to technically by the majority of North American writers as *Listroderes obliquus* Gyllenhal and as *L. costirostris* Schoenherr by writers in other countries, its correct technical name, according to Buchanan (*2*), is *L. obliquus* Klug.

The vegetable weevil has been known and mentioned in the literature by several common names, including the Australian tomato weevil (*3*, *4*, *5*), the buff-colored tomato weevil (*9*), the brown vegetable weevil (*16*, *17*), the carrot weevil (*16*), the dirt-colored weevil, and the turnip weevil (*1*). In 1931 the name "vegetable weevil" was approved by the American Association of Economic Entomologists (*1*).

[3] Reported as *Hypera* sp. by T. D. Urbahns (U. S. Bur. Ent., Insect Pest Survey Bull. 6:43. 1926).

ECONOMIC IMPORTANCE

It is difficult to estimate the monetary loss chargeable to the depredations of the vegetable weevil in the United States because of the many factors involved. Not only commercial vegetable growers are affected, but also an infinite number of home gardeners. The insect not only attacks field-grown crops, but often causes serious injury to crops grown in coldframes, hotbeds, and seedbeds. Furthermore, the degree of vegetable weevil infestation and crop loss varies

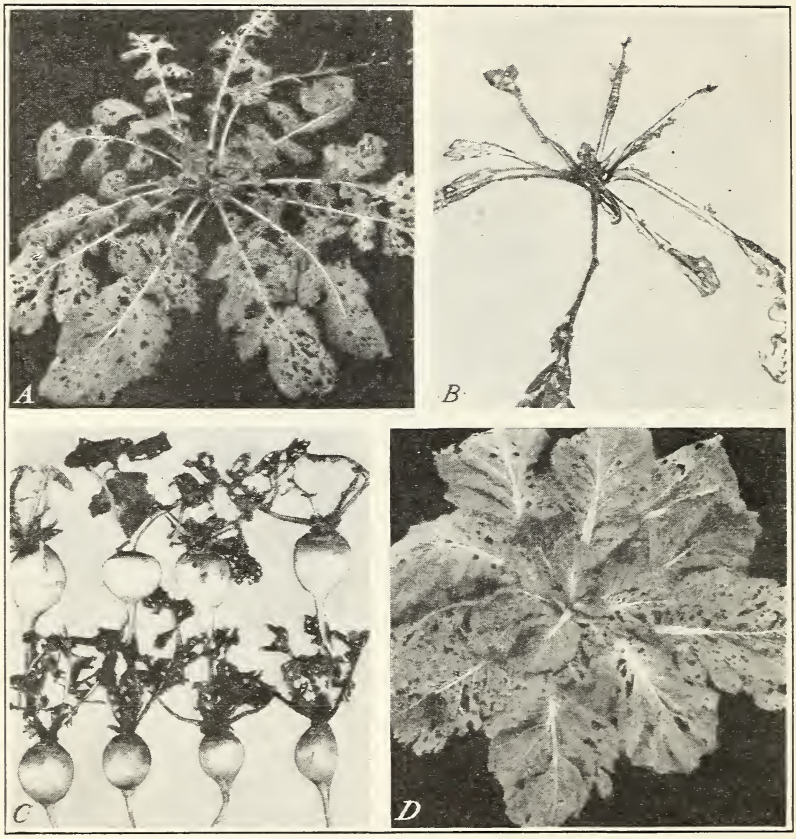

FIGURE 4.—Injury by larvae of the vegetable weevil to vegetable tops: *A*, Turnip plant still alive; *B*, turnip plant dead: *C*, turnips showing injury detrimental to marketing; *D*, broadleaf mustard.

sharply from season to season and also with different crops. One crop planted in a given field may be badly injured, or totally destroyed for market purposes, whereas a catch crop planted to replace the ruined crop in the same field may develop to the harvest stage without being appreciably damaged.

The primary injury by the vegetable weevil larvae is caused when they devour the buds of the host plants, stunting them (fig. 3), and later the foliage, with the exception of the main stems and larger veins.

The loss of the leaves not only interferes with the normal functioning of the plants but affects the market value of the crops (figs. 4, *C*; 5). In the South the leaves of turnips have a greater market value than the roots. Even though the infestation is not severe enough to cause noticeable injury, the mere presence of the larvae lowers the market value of the crops.

Growers in the Crystal Springs district of Mississippi have reported losses as high as 90 percent, and losses of 40 to 70 percent are frequent. During 1933 the estimated crop losses for tomatoes alone ranged from 5 to 70 percent of the total value of the crop. Normally 15,000 acres or more are planted to this crop each year in this district. Entire plantings of turnips (fig. 6), carrots, cabbages, mustard, and spinach have been destroyed or injured seriously during the early stages of growth by this weevil, and the growing of carrots on a commercial scale in this district has been practically abandoned. The injury, particularly to tomato and eggplant, has been observed both in the field and in hotbeds and coldframes. Practically all vegetable growers in this and many other districts adjacent to the Gulf of Mexico have suffered crop losses as a result of the feeding of the weevil.

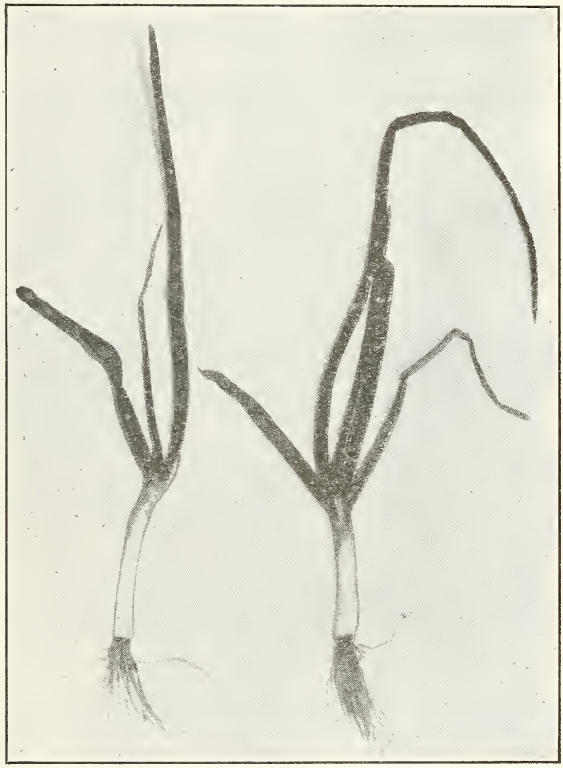

FIGURE 5.—Onion tops injured by vegetable weevil larvae. The larvae often tunnel inside the leaves.

Since the commercial and home-grown vegetable crops that are hosts of the vegetable weevil in the 10 States known to be infested have been valued at approximately $163,500,000 (census of 1930), some idea of the potential menace of this pest to the vegetable industry can be gained from the damage it has caused in the districts where it is already established.

FOOD PLANTS

For several seasons after the discovery of the vegetable weevil in this country its depredations were confined principally to potatoes, tomatoes, turnips, and carrots. In succeeding years, however, it has been observed attacking other plants. At the end of 1935 the

following food plants of the weevil and its larva, listed in approximate order of preference, had been recorded in the Southern States:

Vegetables: Turnip (figs. 4, *A*, *B*, *C*; 6), carrot (fig. 3), mustard (fig. 4, *D*), cabbage, collard, spinach, lettuce, swiss chard, radish, rape, kale, parsley, tomato, potato, endive, broccoli, kohlrabi, parsnip, eggplant, cauliflower, Chinese cabbage, beet, onion (fig. 5), garlic, sweetpotato, pepper, bean, and peanut.

Flowering plants: Verbena, petunia, phlox, pansy, and California-poppy.

FIGURE 6.—General view of turnip field where the foliage and roots were damaged seriously by the vegetable weevil.

Wild host plants:	Stages feeding
Alsine media (L.) Cyrill. (common chickweed)	Larva and adult.
Ambrosia elatior L. (small ragweed)	Larva.
Antennaria sp. (pussytoes, ladies' tobacco)	Larva and adult.
Aster tenuifolius L. (wild aster, or perennial salt marsh aster).	Do.
Buddleia asiatica Lour. (white butterfly bush)	Adult.
Cerastium viscosum L. (mouse-ear chickweed)	Larva and adult.
Chenopodium album L. (lambsquarters)	Do.
Chenopodium ambrosioides L. (Mexican-tea)	Do.
Cirsium horridulum Michx. (yellow thistle)	Larva.
Cirsium lanceolatum (L.) Hill (bull thistle).	
Cirsium muticum Michx. (swamp thistle)	Larva.
Coreopsis basalis (Dietr.) Blake (tickseed)	Do.
Datura stramonium L. (jimsonweed)	Larva and adult.
Erigeron sp. (fleabane)	Larva.
Eupatorium capillifolium (Lam.) Small (dogfennel)	Larva and adult.
Eupatorium coelestinum L. (mistflower)	Do.
Geranium carolinianum L. (Carolina cranesbill)	Larva.
Geranium sp.	Do.
Gnaphalium purpureum L. (purplish cudweed)	Do.
Helenium tenuifolium Nutt. (bitterweed)	Larva and adult.
Hydrocotyle bonariensis Lam. (water pennywort)	Larva.
Hydrocotyle ranunculoides L. (floating marsh pennywort)	Do.

Wild host plants—Continued.	Stages feeding
Lactuca sp. (wild lettuce)	Larva and adult.
Lanium amplexicaule L. (henbit)	Do.
Lepidium sp. (peppergrass)	Larva.
Lepidium virginicum L. (wild peppergrass)	Do.
Linaria canadensis (L.) Dumont (blue toadflax)	Do.
Malva sp. (mallow)	Do.
Morus alba L. (white mulberry)	Adult.
Modiola caroliniana (L.) G. Don	Larva.
Oenothera laciniata Hill (cut-leaved evening-primrose)	Do.
Oenothera speciosa Nutt. (evening-primrose)	Do.
Oxalis corniculata L. (creeping oxalis or lady's sorrel)	Larva and adult.
Oxalis stricta L. (common yellow oxalis)	Do.
Plantago virginica L. (white dwarf plantain)	Larva.
Polygonum punctatum Ell. (water smartweed)	Larva and adult.
Rumex verticillatus L. (swamp dock)	Do.
Scutellaria integrifolia L. (larger or hyssop skullcap)	Larva.
Sitilias caroliniana (Walt.) Ref. (false dandelion)	Do.
Sonchus asper (L.) Hill (spiny-leaved sowthistle)	Larva and adult.
Verbascum sp. (mullein)	Do.
Verbena bipinnatifida Nutt. (Dakota verbena)	Do.
Veronica peregrina L. (purslane speedwell)	Do.

In California Lewis (*13*) recorded the following host plants of the vegetable weevil adult, listed in order of preference: Potato, tomato, pear (foliage), turnip, carrot, spinach, wild parsnip or poisonhemlock (*Conium maculatum* L.), and milkthistle (*Silybum marianum* (L.) Gaertn.). He also recorded 17 host plants of the larva. In a later publication (*14*) Lewis and Gammon reported the following cultivated truck crops as being attacked by the larvae in California: Turnips, carrots, spinach, radishes, potatoes (leaves), tomatoes (leaves), parsnips, celery, celeriac, Swiss chard, sweet anise, parsley, table beets, broccoli, cauliflower, cabbage, kale, kohlrabi, salsify or vegetable-oyster, lettuce, endive, dandelion, dill, onion, leek, artichoke (leaves), and cardoon (leaves). The following weed hosts of the larva were also mentioned: *Malva* sp., nettle (*Urtica urens* L.), *Amaranthus* spp., milkthistle, wild parsnip, mustard (*Brassica campestris* L.), *Rumex* spp., and horehound (*Marrubium vulgare* L.). The authors conclude that in heavy infestations the larvae will feed on plants that they would otherwise not attack and under favorable conditions will feed on almost any green and succulent plant. According to Lovell (*15*) the vegetable weevil adult also fed on collards and chickweed and the larva on ragweed and wild aster.

In Australia French (*6*, *7*) recorded the weevil as being very destructive to tomatoes, cabbages, and other vegetables. In another publication (*8*, *pp. 41–43*) he stated that some of the weevils of the genus *Desiantha*, in which the vegetable weevil was once placed, fed on the buds of plum and other fruit trees. McCarthy (*16*, *17*) stated that potatoes and tomatoes were the most favored cultivated hosts, and that the weevil had been recorded frequently on cucumbers, beans, carrots, parsnips, turnips, lettuce, and chrysanthemums, and on one occasion on young tobacco plants in seedbeds. The weevil also fed commonly on Cape weed (*Cryptostemma calendulaceum* (L.) R. Br.), a plant introduced into Australia from South Africa, and appeared to prefer it to either potatoes or tomatoes.

DESCRIPTION

EGG

The egg is spherical or slightly elliptical and is a little less than 1 mm. in diameter. When first deposited it is creamy white, but soon changes to a dark yellow, and just prior to hatching it is black. The surface of the chorion is smooth and shiny.

LARVA

The larva (fig. 7, *A*) is of the usual curculionid form, slender, strongly convex, and flattened on the ventral surface. When first hatched it is creamy white but shortly after it assumes a pale-green color, and later a darker green color, depending on the host plants present and the food it consumes. It ranges in length from about 1.9 mm. when first hatched to about 14 mm. when full grown. The head ranges from light yellow to brown and is variegated with a

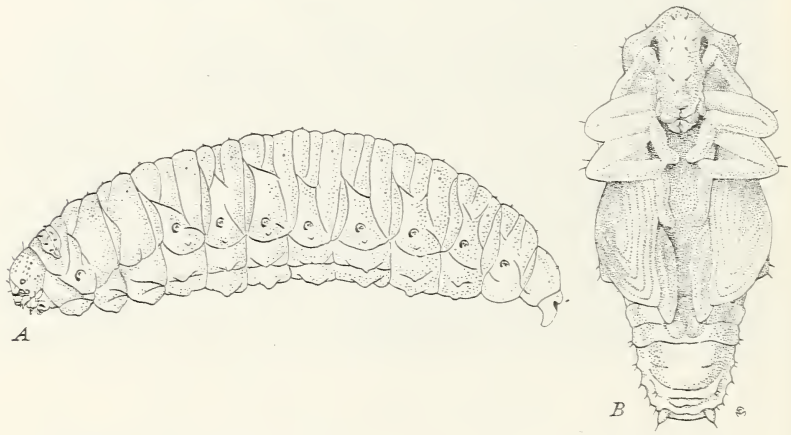

FIGURE 7.—The vegetable weevil: *A*, Larva, ×15; *B*, pupa, ×19.

series of brown dotted lines forming a distinct pattern. The prothoracic shield is narrow, divided at the middle, paler than the head, and bears a pattern of dots that form two darkened areas in the prothorax back of the head. The ventral surface has no distinct prolegs, but bears flexible fleshy joints from which project ventral and lateral lobes that serve as organs of locomotion. The circulatory system, forming a dark medial line, is visible through the dorsal surface. The larva has four molts or stages. After each molt the head is almost white, but it soon becomes dark brown.

PUPA

The pupa (fig. 7, *B*) is about 7.5 mm. long, or a little shorter than the adult, and over half as wide as long. The head is white, the legs and wing pads are yellow, and the abdominal segments pale green. The rostrum, or beak, is broad and is folded back along the body to about the middle of the first pair of legs. The vertex bears a pair of short, stiff, black spines, and two pairs and a row of four spines occur lower on the rostrum. Similar spines are present at the apex of the thorax

on each side, at the knees, on the apical segments of the abdomen, and on the dorsum of all the abdominal segments.

ADULT

The adult female weevil (fig. 8, *A*) is a typical curculio or snout beetle of medium size. It is about 9 mm. long and 4 mm. wide. The color is dull gravish brown, and each elytron or wing cover has a pale-gray mark. When the elytra are folded these marks form a V-shaped figure, back of which there is a pair of small tubercles, which protrude posteriorly. The beak is short and stout, bearing clubbed and geniculate (elbowed) antennae or feelers. The prothorax is widened anteriorly. The body is clothed with buff and gray scales and with scattered hairs.

No males of the vegetable weevil have yet been found in the territory covered by these investigations in the Southern States.

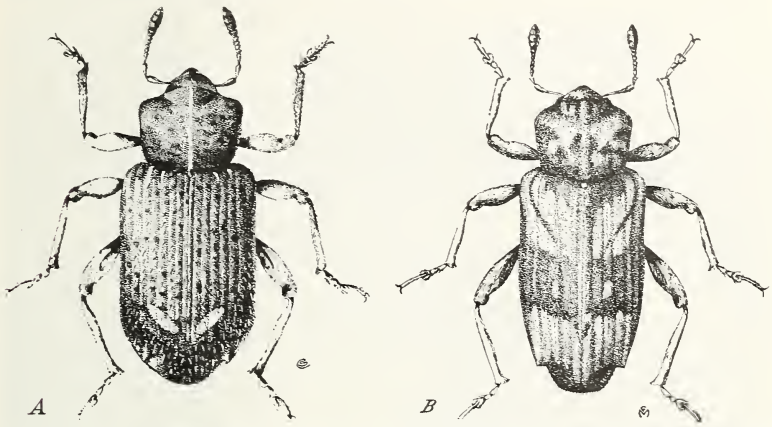

FIGURE 8.—*A*, Adult of the vegetable weevil; *B*, adult of the banded vegetable weevil. ×7.

CLOSELY RELATED SPECIES

Another weevil, identified as *Listroderes apicalis* Waterh. and commonly called the banded vegetable weevil (fig. 8, *B*), is often found attacking vegetables in association with the vegetable weevil. According to specimens in the United States National Museum collection, this closely related species has been found only in the following localities: Gulfport and Guntown, Miss.; Covington, Hammond, Ruston, Grand Bay, Tallulah, and Baton Rouge, La.; and Experiment and Fort Valley, Ga. One specimen was also found on the deck of a ship at New Orleans, La. It injures vegetables in much the same manner as the vegetable weevil, but differs from it in that both sexes are represented. On a number of occasions the male of *L. apicalis* has been mistaken for the male of *L. obliquus*. The vegetable weevil is slightly larger and darker in color than *L. apicalis* and possesses the characteristic light-colored V-shaped figure on the wing covers, whereas *L. apicalis* is a lighter shade of brown with a light-colored bar extending across the rear of the elytra. The posterior elytral tubercles in

apicalis are more prominent than in *obliquus*. On one or more occasions *Euparius marmoreus* (Oliv.), *Hyperodes* sp.,[4] and *Pnigodes setosus* Lec. have been found associated with the vegetable weevil and *L. apicalis* Waterh. in fields.

LIFE HISTORY AND HABITS

METHODS OF STUDY

Studies on the life history of the vegetable weevil were begun in February 1925, with larvae collected at Handsboro and Cedar Lake, Miss., and were continued through 1933. As soon as the larvae pupated, the pupae were isolated in 6-ounce tin ointment boxes

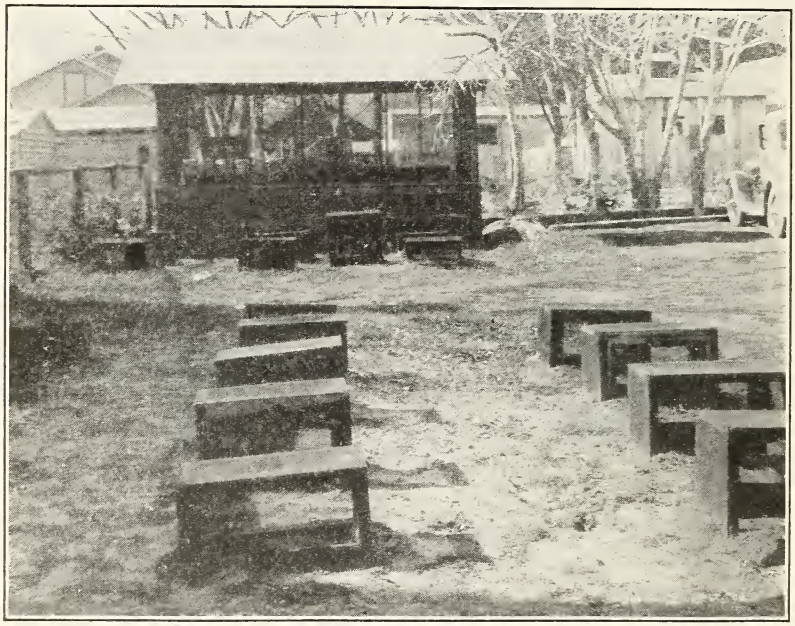

FIGURE 9.—Cages used in life-history studies and in poisoned-bait experiments with the vegetable weevil.

partly filled with soil. Approximately 25 percent of the boxes in this first rearing contained two pupae each and the others, as well as those in later rearings, contained only one. After emergence the weevils were fed turnips or carrots throughout the spring and summer. Early in the fall they were transferred to fresh 4- or 6-ounce tin ointment boxes filled with soil or sand. The weevils became active and fed freely. During the period when eggs were being deposited, each weevil was transferred daily to a new container and supplied with fresh food. Throughout one season jelly glasses were used as containers for a portion of the rearings to determine whether a different type of rearing cage would affect insect development. These glasses were discarded, however, in favor of the tin ointment boxes, which

[4] Determined by L. L. Buchanan, Division of Insect Identification, Bureau of Entomology and Plant Quarantine

allowed more accuracy in the daily examinations. Observations and records were made daily on the number of eggs deposited, the number hatching, growth of larval stages, date of pupation, and date of emergence. Temperature and humidity were recorded by a hygrothermograph placed near the boxes. Part of the time the rearing cages and the soil were sterilized. The weevils oviposited in the turnips and carrots which had been furnished as food.

Practically all the life-history studies were made in an open insectary. As a check, weevils were placed on turnips in screened cages out of doors (fig. 9), and frequent observations were made of the number of eggs deposited per female and the depth to which larvae burrowed in the soil for pupation. Field observations also were made at frequent intervals. Some comparative experiments were performed with weevils collected in the field to determine whether the reactions of these insects varied from those of weevils reared in confinement.

EGG

Life-history studies under cage conditions showed that the length of the incubation period is influenced greatly by the temperature. For example, on the Gulf coast this period ranged from 15 to 33 days when the average daily mean temperature ranged from 55° to 76° F. (table 1). During the spring and fall most of the eggs under observation hatched within 15 to 20 days after deposition.

TABLE 1.—*Developmental period of the vegetable weevil at Gulfport, Miss., 1925–33*

Experiment No.	Average daily mean temperature	Date egg was deposited	Date of adult emergence	Incubation period	Larval period	Pupal period	Developmental period
	°F.			*Days*	*Days*	*Days*	*Days*
1	68	Feb. 26	Apr. 25	16	29	13	58
2	68	Feb. 28	Apr. 23	17	23	14	54
3	76	Mar. 14	May 1	15			48
4	56	Nov. 3	Jan. 29	18	42	27	87
5	56	Nov. 7	Feb. 7	18	45	29	92
6	55	Nov. 10	Mar. 1	33	39	39	111
7	56	Nov. 16	Feb. 22	21	44	33	98
8	57	Nov. 17	Feb. 11	26	38	22	86
9	58	Dec. 7	Feb. 23	17	43	18	78
10	55	Dec. 19	Apr. 5	24	42	41	107

LARVA

Immediately after hatching the vegetable weevil larvae begin feeding, usually on the buds of the host plants or on the under sides of the leaves close to the buds. Later in their development the larvae feed on all foliage parts (fig. 4, *A*, *B*), and with such crops as turnips and carrots they feed often on and severely injure the roots (fig. 10, *A*, *B*). The holes made in the leaves by the small larvae are round, whereas those made by the large larvae are irregularly shaped. When the larvae are numerous, approximately 10 to 25 per plant, the leaves are skeletonized, with only the main stems and larger veins remaining (fig. 4, *A*, *B*). When attacking onions (fig. 5) the larvae often tunnel inside the leaves.

The larval period under cage conditions in Mississippi varied greatly with the temperature and moisture. The individuals under observation completed their larval growth in 23 to 45 days, with an average of approximately 38 days (table 1).

PUPA

After the last molt the larva enters the soil and forms an earthen cell, within which it undergoes a resting or prepupal stage. The length of the prepupal stage varies with the season of the year and with weather

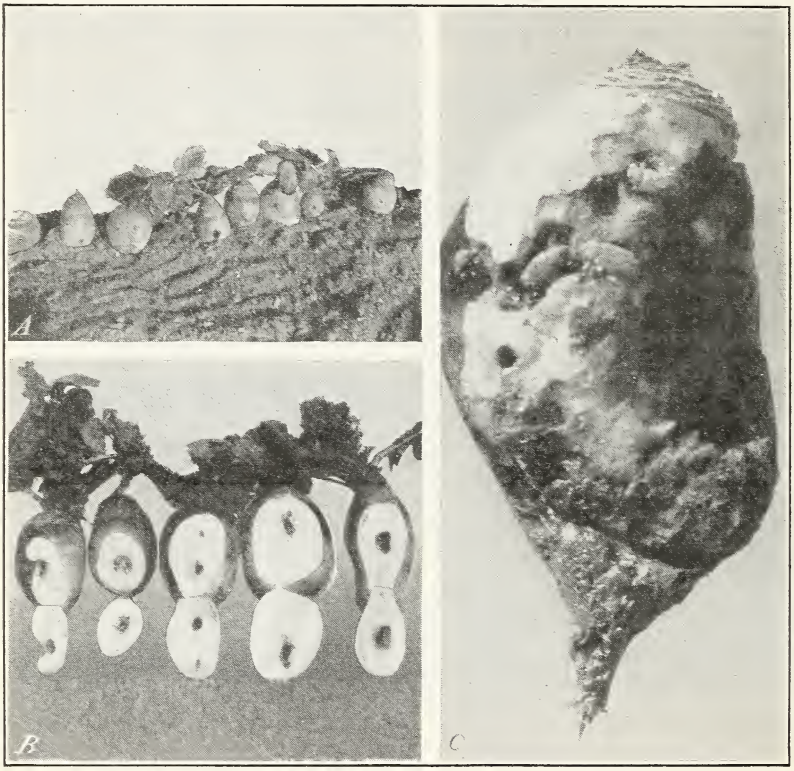

FIGURE 10.—Injury by vegetable weevil to turnip roots: *A*, Whole roots from which soil has been removed to show entrance to larval feeding tunnels; *B*, roots sectioned to show larval injury to the interior; *C*, root injured by adults, with weevils in typical feeding position.

conditions. It may last only a day or two or it may require 2 or more weeks. On lowland where the soil-moisture content is high or when the temperature is low the resting stage is prolonged. Larvae entering the soil late in the fall and winter are much slower in transforming to pupae than are those entering the soil in the spring. Just before pupation the larvae are lighter in color than when they are in the active stage. Mature larvae, if disturbed just after constructing their cells, will immediately begin repairing the cells before transforming into pupae.

The pupae are found in the soil near the host plant. The depth at which pupae are found varies with the texture and moisture content of the soil, but usually ranges from ½ to 2 inches. In dry cracked soil pupae have been found at depths of 6 to 9 inches. The pupal period ranged from 13 to 41 days (table 1).

ADULT

EMERGENCE FROM PUPA

As the pupa transforms into the adult weevil, the first noticeable change is in the coloration of the wing pads from creamy white to light brown. After transformation the adult remains a few days in the pupal cell until the body tissues are sufficiently hardened to enable the weevil to emerge from the soil. At the time it emerges it is conspicuously marked with a pale-gray V-shaped figure on the elytra and is light brown. Both these features are obscured during the life of the weevil, since the characteristic dull grayish-brown color soon becomes predominant. The newly emerged weevils are voracious feeders and seek food immediately after emergence.

FEEDING HABITS

Active feeding by the adults occurs generally from the middle of September to the middle of the following June. In the summer months the adults ordinarily become inactive, except for occasional periods of slight feeding activity. That the adult weevils are able to survive for long periods without food was shown by a series of experiments in cages during the summer of 1928 and again during the summer of 1933. In these experiments the adults were confined without food in tin ointment boxes and in jelly glasses. Under these conditions the majority of the weevils lived from 70 to 90 days, whereas 8 percent of the weevils were alive after 266 days, and one individual lived 310 days.

In general the weevils feed mainly on the foliage of their host plants, but under some circumstances they feed on the roots of such vegetables as turnips (fig. 10, *C*) and carrots. Feeding occurs principally during the night, although weevils have been observed feeding during the day when heavy foliage afforded them protection against direct sunlight. Usually, however, the weevils hide in the daytime under leaves, clods of soil, or other objects on or close to the surface of the soil.

During the spring the adults often cause extensive damage by feeding on the leaves of small tomato and potato plants and by cutting off the stems of plants at the ground level, the injury resembling that of cutworms. Later in the development of the plants the weevils devour the buds and leaves. At this season the newly emerged adults are present commonly in such numbers as practically to defoliate, within a period of a few nights, such crops as turnip, mustard, and cabbage growing in small gardens. Under such circumstances as many as 15 to 49 newly emerged weevils have been collected from beneath a cabbage leaf that was lying flat on the soil surface. In lowland, subject to overflow during heavy rainfall, the adults have been observed feeding at night on cabbage that projected above the level of the water. As many as 20 weevils have been taken from a single head of partly submerged cabbage.

ESTIVATION

As the temperature rises early in the summer, the adults enter a period of inactivity which will be referred to as estivation. Except for occasional short intervals of activity and feeding, they remain in this condition from the first part of June until the last of September. During this period the adults may be collected in large numbers under old straw and rubbish around the edges of gardens and fields. One such occurrence was observed at Picayune, Miss., May 18 and 19, 1933, when old straw was moved from its original position and the sheltered weevils were exposed to the sun. Immediately these weevils became very active and were easily collected when they attempted to seek shelter from the heat. On June 6, 1933, and on previous occasions, adult weevils were collected under the loose bark of pecan trees at Long Beach, Miss., at heights ranging from only a few inches to 6 feet above the soil surface. These collections indicate that the weevil will seek any convenient shelter during the summer, whether it be dead grass or straw, the loose bark of trees, or rubbish.

In the absence of shelter on or above the soil surface, the weevil adults have been found at depths ranging from 1 to 3 inches in finely pulverized soil during the early part of the summer, but it is surmised that the soil was used only as a temporary retreat, since late in the summer it is difficult to locate weevils in the soil.

The temperature and available food supply seem to be important factors affecting the time the summer period of inactivity begins, the temperature having the greater influence since the weevils naturally become sluggish on the approach of hot weather.

The weevils emerging early in the winter seek shelter before those emerging late in the spring, provided the food supply has been equal throughout the feeding period.

The mortality of adults during the summer months varies greatly, depending on the weather and other natural factors. Under cage conditions weevil mortality during the summers of 1928–32 ranged from 40 to 90 percent. It is believed that this mortality was due in part to cage restrictions. Although no exact information was obtained regarding summer mortality under field conditions, large numbers of dead weevils were found frequently in typical estivating quarters late in the summer.

PROTECTIVE HABIT

The vegetable weevil when disturbed will at times feign death, falling upon its back or side with the legs either spread widely apart or drawn together under the body, and with the antennae drawn alongside the beak. In this position the weevil will remain motionless as long as there are unusual noises or activities in the vicinity. This habit of feigning death, together with its dull grayish-brown color, makes the mature weevil difficult to detect among clods of soil.

DISSEMINATION

The vegetable weevil may be disseminated by natural or artificial means. In the Southern States it has spread northward, eastward, and westward at a rate of approximately 50 miles a year. The fact that dissemination has been more rapid in the open cultivated sections than in the wooded sections indicates that heavy forest growths

may retard the normal rate of dispersal. Numerous observations in the field suggest that flight may be one means of dissemination. Inspections during the summer in some of the fields that were heavily infested the previous spring have failed to reveal the presence of the weevil, whereas in fields that were free of infestation during the spring large populations of estivating weevils were found. Ordinarily the weevil crawls rather slowly and it is doubtful whether it disperses in this manner farther than to some neighboring host plant, field, or farm. In the Gulf coast section, where the vegetable-growing districts are often separated by large areas of cut-over lands, it is believed that dispersion occurs principally through flight.

The ability of the weevil to fly was first observed in November 1927 while examinations were being made in large cages. During a period of 5 minutes 5 weevils were observed to take wing and fly about in the cages. Within a period of 31 minutes 23 weevils were observed in flight. This unusual activity occurred during midafternoon when part of the cage was exposed to the sun and when the temperature was 82° F. It is possible, however, that the direct sunshine and high temperature caused the weevils to seek their normal environment of shade and relatively low temperature.

The weevils occasionally took wing when liberated on some elevated object exposed to the sun and in the absence of strong winds. Usually the wings are spread as if to exercise them before the flight actually takes place. Attempts to force the weevils to fly on windy days have been unsuccessful.

On the basis of observations thus far, it is concluded that winds may function in the dispersion of the weevil, since it has been determined that dissemination proceeds more rapidly in the open country than in sections interspersed by woodlands, although long-distance dispersion of the weevil in this manner has not been observed. In this connection it is probably significant that one county in Mississippi which was nearly surrounded by wooded areas remained free of the weevil from 1 to 4 years after infestations had been found in adjacent counties.

The dispersion of the vegetable weevil by artificial means seems obvious since turnip greens, mustard, cabbage, radishes, carrots, endive, parsley, parsnips, onions, and collards have been found infested with weevil larvae after these crops were ready for market. During the height of the breeding season the weevil can be transported easily from place to place through the shipment of green vegetables and such root crops as turnips and carrots, either on the plants or secluded in the shipping containers. In all probability it was through this medium that the weevil was taken aboard ship and brought to this country. Repeated observations have demonstrated that the pest may be accidentally transported by persons or vehicles.

PREOVIPOSITION PERIOD

The age at which oviposition begins varies to some extent with the individual weevil and with the season. In general the weevils emerging during the winter and spring do not deposit eggs until the following fall and winter. After coming out of estivation the weevils feed for a period ranging from a few days to more than a month before they begin ovipositing. Therefore the preoviposition period, or the

total time from emergence to first oviposition, may range from 6 to more than 8 months.

OVIPOSITION

The vegetable weevil deposits its eggs on plants and on or in the soil nearby. Usually the crowns of the plants are the preferred locations when ample moisture is present. After depositing the eggs on the leaves or stems, the weevil attaches them to the leaves by a glutinous secretion exuded at the time of oviposition. In the soil the weevil constructs a small pocket with its ovipositor before depositing the eggs. Ordinarily the eggs are deposited singly, although masses of two to eight or more eggs are sometimes found. Weevils depositing only infertile eggs often oviposit in masses.

PARTHENOGENESIS

The percentage of eggs that hatched in the experimental cages ranged from 0 to nearly 100. Most of the weevils under observation deposited only fertile eggs throughout life, whereas some deposited only infertile eggs after they were confined in cages. Other individuals deposited fertile eggs when first confined, but later produced only infertile eggs. When depositing fertile eggs the weevils showed more discrimination in placing the eggs in suitable locations for the feeding and development of the resulting larvae than when depositing infertile eggs. Usually the weevils ovipositing most freely would produce infertile eggs. Many of these infertile eggs were deposited at random on the cage and on the soil.

In the course of laboratory rearings and collections in the field, extending over a period of several years, no males of the vegetable weevil have been found, and all observations indicate that reproduction of the species occurs parthenogenetically.

LONGEVITY

Judging from data obtained under cage conditions, the length of life of the vegetable weevil adult is approximately 12 months, but varies with weather conditions and food supply. Prolonged exposure to excessive moisture proved fatal to the weevil adults, whereas the practical absence of moisture, in the presence of high temperatures, greatly shortened the life period. Three weevils used in the life-history studies lived 21, 22, and 23 months, the maximum longevity observed.

OVIPOSITION PERIOD

The oviposition period of 29 weevils observed in cages ranged from 63 to 395 days. Fourteen of the weevils deposited eggs for more than 300 days, 11 for more than 100 days, and 4 for less than 100 days. These weevils died within a few days after the last of their eggs had been deposited.

TOTAL LIFE CYCLE

Under cage conditions in Mississippi the time required for a complete life cycle of the vegetable weevil during the spring and early fall ranged from 48 to 111 days (table 1).

SEASONAL OCCURRENCE

In the Gulf coast section there is only one generation of the vegetable weevil annually. The period of occurrence of each stage of the weevil (fig. 11) is influenced by climatic and crop conditions.

ADULTS

In the Gulf coast section the emergence of vegetable weevil adults from pupae ordinarily begins early in December and terminates the middle of June. Newly emerged adults have been collected as late as June 12, but the peak of emergence has occurred between December

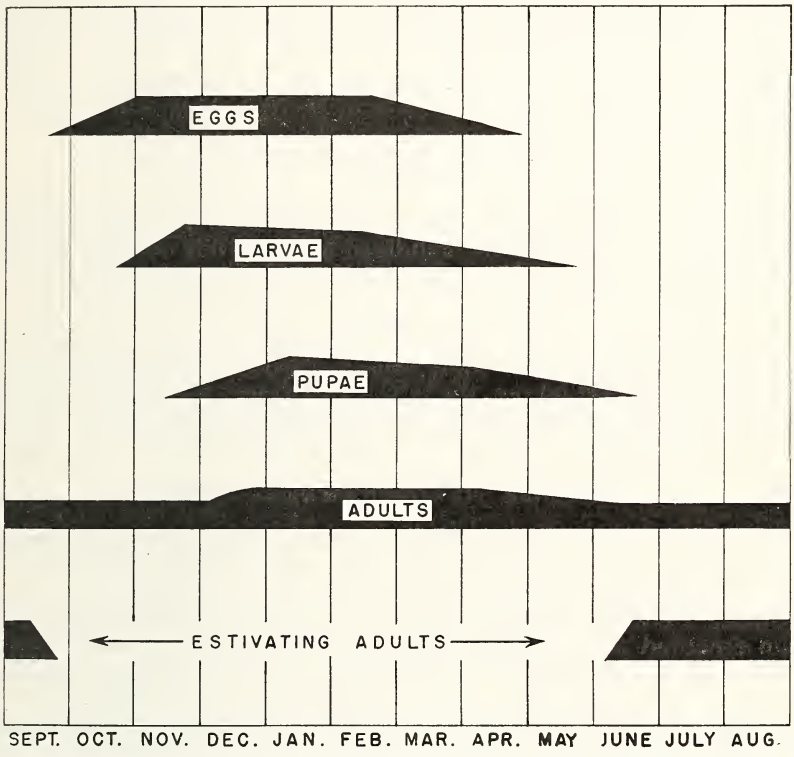

FIGURE 11.—Seasonal occurrence of the vegetable weevil in Mississippi, 1922–33.

and May. In some years, however, a late spring has prolonged the period of adult emergence, apparently because low temperatures have extended the normal oviposition period of overwintered adults.

The duration of the first feeding stage of the adult is governed almost exclusively by climatic conditions. When the spring is late the weevils feed for a longer period than usual. When warm weather occurs early, they feed heavily for a few weeks and then gradually seek shelter for the approaching period of summer inactivity. Under average conditions the majority of the weevils enter the inactive stage early in June (fig. 11).

About the last of September the adults leave their hiding places and resume their feeding activities on various host plants. After feeding for a short time they begin to deposit eggs.

The adults occur in the field throughout the entire 12-month period each year, but are present in greatest abundance from the last of December to the middle of April (fig. 11).

EGGS

In the Gulf coast section egg deposition normally begins late in September and continues until the last of April (fig. 11), but this period varies greatly with the temperature. If oviposition begins early in the fall, as a result of certain individuals having been brought out of estivation by temperatures that were low enough to stimulate activity, egg deposition by these individuals will be completed before cold weather. On the other hand, if high temperatures postpone emergence from estivation until late in the fall, such adults will not deposit their complement of eggs until the following spring.

LARVAE

Normally vegetable weevil larvae are found in the field from the last week of October until the middle of May. They occur in greatest abundance during December, January, and February (fig. 11).

PUPAE

Although subject to the same seasonal variation and occurrence as the adults, eggs, and larvae, the pupae are present in the field during a normal season from the middle of November until the middle of June, the peak of abundance occurring in January (fig. 11).

RESPONSE TO LOW TEMPERATURES

Repeated observations in the field and in cages have demonstrated that all stages of the vegetable weevil will survive relatively low temperatures.

During December and January of the winter of 1929–30 the minimum recorded temperatures in the truck-crop district near Crystal Springs, Miss., were below freezing 29 days, with a low point of 7° F. (fig. 12), such temperatures being unusually severe for that section of the country. Eight inches of snow fell on December 22 and 1 inch on January 18 and 28. This resulting blanket of snow may have afforded some protection for the vegetable weevil.

To determine the effect of the adverse climatic conditions on the vegetable weevil, many field observations were made during the cold weather, including collections of the insect from plants that had not been killed by the freeze. Many of these plants were partly covered with snow.

The freeze had killed the tops of most of the turnips and caused the roots to rot. Near the edge of one field a living turnip top was found and two larvae about 10 days old were collected from the leaves. In the soil close to the turnip roots a number of prepupae were collected, none of them more than 2 inches below the surface. Living adults were found at a depth of 2 inches in the soil. Larvae that appeared

to be only 4 or 5 days old were also found feeding on mustard, apparently unaffected by the low temperatures. Eggs were collected from mustard, from Johnson grass, and from the soil. The eggs were yellow, indicating that oviposition had occurred prior to the freezes. One living adult was found in a crown of Johnson grass, and many living weevils were collected beneath grass and rubbish along the margins of the fields. These adults were found in practically the same situations as during estivation. The temperature ranged from approximately 40° to 50° F. on the days these collections were made.

Living larvae, pupae, and adults of the vegetable weevil were collected in fields near Perkinston, Miss., 2 days after a minimum temperature of 18° F. had been recorded, and subsequent observations disclosed that none of the weevils showed any adverse effects from exposure to this temperature.

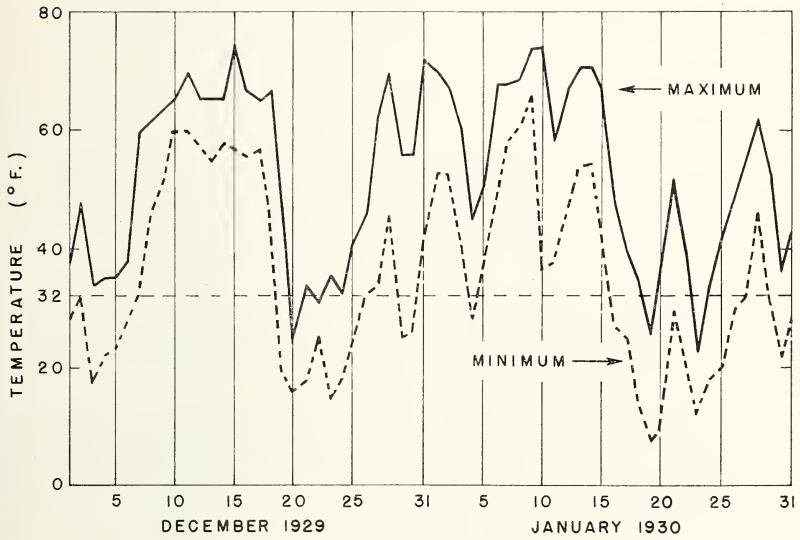

FIGURE 12.—Daily maximum and minimum temperatures at Crystal Springs, Miss., during December 1929 and January 1930.

The capacity of the weevil to withstand moderately low temperatures by remaining quiescent until the temperature rises indicates that it can tolerate a greater range of temperature exposure than was expected.

NATURAL CHECKS

Although many thousands of eggs, larvae, pupae, and adults of the vegetable weevil have been under observation, in cages and in the field, each season during the progress of the investigations reported upon in this circular, the only evidence obtained regarding direct parasitization of the insect consisted of the finding of a few specimens of nemas within the bodies of dead adults found in the field. These nemas were identified as belonging to the genus *Diplogaster*,[5] several species of which are known to be parasitic on insects. A review of

[5] Determined by N. A. Cobb, Bureau of Plant Industry.

the literature on the vegetable weevil has failed to disclose any records of parasitization of this insect.

The vegetable weevil is preyed upon by several species of spiders and ants. The fire ant (*Solenopsis xyloni* McCook)[6] has been found to destroy large numbers of larvae, pupae, and adults in insectary cages, as well as adult weevils that had been made inactive by poison or by other causes in the fields. The ants have been observed to attack eggs and newly hatched larvae repeatedly in the fields. On several occasions *Solenopsis pergandei* Forel.[6] and the thief ant (*S. molesta* (Say)) have been found attacking larvae. Along the Gulf of Mexico these ants are abundant and assist in destroying large numbers of immature forms of the vegetable weevil during the fall, winter, and spring.

Field observations in the Southern States have demonstrated that guineas, chickens, and other domestic fowls are of considerable value locally in lessening the damage caused by the vegetable weevil. The writer observed that a large number of small gardens and fields were protected from weevil injury by the feeding of young guineas and chickens that had the run of the premises. Some growers have used flocks of young guinea fowls and chickens to clean up heavy infestations after the crops had been so badly damaged that they had no marketable value. In some fields this practice has reduced the population of the vegetable weevil to such an extent as to prevent severe infestations to crops planted the following season. It therefore appears feasible to use fowls as a control measure for the vegetable weevil.

Sparrows, meadowlarks, mockingbirds, and blackbirds have been repeatedly observed feeding on larvae of the vegetable weevil. No stomach examinations of these birds were made, however, to authenticate these observations.

Dead weevils have been observed in the field frequently during these investigations. In March 1931 a large number of weevils died just before or after emerging from the soil. It was suspected that this mortality was caused by disease, but a study failed to reveal the presence of any primary disease organisms.

CONTROL

Although satisfactory control methods for the vegetable weevil have not yet been devised, experiments and field observations have shown that, in addition to the use of domestic fowls as predators in small gardens and small fields, clean cultivation, crop rotation, poisoned baits, and insecticides will aid greatly in curtailing damage by this pest.

CLEAN CULTIVATION

During the summer when the weevils are in estivation along fence rows and ditch banks and beneath dead grass and rubbish in or close to infested fields, large numbers of weevils can be destroyed by thoroughly cleaning up such places by burning or by otherwise disposing of all available shelter. This clean-up should include the removal of loose bark from trees located in or bordering fields, since many weevils commonly find shelter underneath such bark.

[6] Determined by M. R. Smith, Bureau of Entomology and Plant Quarantine.

Since large numbers of immature weevils are present in the soil at depths ranging from a half inch to several inches during the winter and early in the spring, frequent plowing followed by harrowing will destroy many of them directly or indirectly by exposing them to predacious enemies.

Not only should susceptible crops be thoroughly cultivated but the borders of the fields should be kept as clean as possible of the common chickweed and other wild host plants of the vegetable weevil.

CROP ROTATION

In localities where the weevil is a serious pest, populations can be kept down by crop rotation. In other words, the preferred host crops should not be planted in the same field or adjacent fields in successive years.

POISONED BAITS

Late in the winter and early in the spring, when the newly emerged adults are abundant around the bases of plants, large numbers may be destroyed by scattering poisoned baits along the edge of the field and between crop rows. The application of baits has given some control, and is therefore of value where the poisoning of foliage by sprays would be a hazard to the consumer. The more effective baits tested thus far during these investigations contain portions of one of the favorite host plants of the weevil, such as turnip or carrot. The bait that has been most satisfactory consists of 1 pound of sodium fluoride, 1 pound of dehydrated carrots or turnips (or 8 pounds of fresh, finely chopped carrots or turnips), and 15 pounds of wheat bran with sufficient water to form a mash. The bait is more attractive to the weevils if allowed to stand several hours before it is applied. To prevent excessive drying out of the bait, it should be scattered late in the afternoon. Baits are effective only late in the winter and in the spring, on the newly emerged weevils, since at other times of the year the weevils prefer the growing crops to the baits. It was observed that when the peak of weevil emergence occurred late, the baits were not so attractive as when it occurred early in the season. From 60 to 100 pounds of bait per acre is necessary, the quantity varying with the degree of infestation and the width of the rows. Baits alone cannot be relied on to effect control; their use must be considered as a supplementary measure in connection with clean cultural methods, crop rotation, and treatment of crop remnants with arsenicals or fluorine compounds.

Lewis (*13*) and Lewis and Gammon (*14*) tested 79 different poisoned-bait combinations in California under cage conditions and in the field. They concluded that none of the baits was entirely satisfactory, but that best results were obtained with a commercially prepared bait of finely ground dried apple pulp and sodium fluosilicate. Lovell (*15*) found that this bait decreased weevil populations when broadcast at the rate of 75 pounds per acre.

INSECTICIDES

Susceptible crops with foliage that is ordinarily not eaten by humans, such as carrots, potatoes, radishes, onions, garlic, sweet-potatoes, peanuts, and small plants of tomato, cabbage, cauliflower, collard, broccoli, and pepper, can be protected from injury by dusting or spraying with any of the commonly used arsenicals or fluorine

compounds. The application of these insecticides to infested crop remnants not intended to be used as food for livestock aids greatly in controlling the weevil by reducing populations that would otherwise infest subsequent crops.

Experiments are being conducted with organic insecticide compounds, particularly derris, pyrethrum, and phenothiazine, in various combinations and dilutions, and with various wetting and spreading agents, to determine their effectiveness as substitutes for arsenicals and fluorine compounds in the control of the weevil on edible foliage, but sufficient information has not been accumulated thus far to warrant a report on this phase of the investigations.

Lovell (*15*) reported that in California infestations of vegetable weevil adults and larvae were best controlled on carrots, turnips, and spinach by applying a dust mixture composed of 70 to 80 percent of either sodium fluosilicate or barium fluosilicate and 20 to 30 percent of diatomaceous earth as a diluent, at the rate of 30 to 40 pounds per acre when the foliage was dense and at 15 to 25 pounds per acre when the foliage was thin. He emphasized that this dust mixture should be distributed evenly on the plants, the first application being made as soon as the damage is observed, and that a rotary duster with a fan-shaped nozzle should be used for small acreages and a power duster for large acreages. For the control of adults or larvae on young tomato plants Lovell recommended that the dust mixture be applied at the rate of 10 to 12 pounds per acre, with a knapsack or bellows duster, a puff or two of the insecticide being delivered to each plant, or a sufficient quantity to cover thoroughly the foliage and the soil at the base of the plant.

Caution: Arsenicals or compounds containing fluorine or barium should not be applied to plants after the appearance of foliage or fruit that will be sent to market or consumed, except in instances where it is known definitely that washing or stripping will remove all harmful residues.

SUMMARY

The vegetable weevil (*Listroderes obliquus* Klug) is an important economic pest in the Southern States and in California. It is believed to be a native of South America and was first discovered in the United States at McHenry, Miss., in March 1922. It appeared first in California in 1925.

The weevil attacks a large number of vegetables, including turnips, carrots, mustard, spinach, tomatoes, and potatoes, as well as ornamental flowering plants and many wild plants. In the Southern States the insect is active throughout the fall, winter, and spring, and estivates during the summer months. It deposits its eggs on the plants and on or in the soil nearby. The larvae cause injury by devouring the foliage and roots of plants. The adults cause the greatest damage in the spring just after emerging. In the Southern States there is only one generation of the insect annually. The length of the developmental period depends on weather conditions. In Mississippi this period ranged from 48 to 111 days.

No parasites of economic importance have been observed. Domestic fowls are efficient in cleaning up infestations in small gardens and small fields. Several species of birds, ants, and spiders also prey upon the weevil, but none of these can be relied on to effect control over large areas.

Although satisfactory control methods for the vegetable weevil have not yet been devised, clean cultivation, crop rotation, poisoned baits, and insecticides, when they can be safely used from the standpoint of human health, have been found to aid greatly in curtailing damage caused by the pest.

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